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SHAWANGUNK MOUNTAIN

BY DR. H. H. HUTTON

UNITED STATES GEOLOGICAL SURVEY



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STEREOGRAM
OF THE
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LEGEND

-  Geological Form
-  Actual Contour

THE
NATIONAL GEOGRAPHIC MAGAZINE

SHAWANGUNK MOUNTAIN *

BY

N. H. DARTON

UNITED STATES GEOLOGICAL SURVEY

Shawangunk † mountain is a prominent range lying between Hudson river and the southern Catskills, in Ulster county, New York. To the eastward it rises from the Wallkill valley to steep inclines, surmounted by a high escarpment; to the westward it slopes to the Rondout valley. Along its axis it rises gradually south of Rosendale, and finally attains an elevation of 2,200 feet and a width of five miles. It continues to the southward, with somewhat decreased height and width, through New Jersey and Pennsylvania, where it is known as Kittatinny mountain, and gives rise to the Delaware, Lehigh and Susquehanna water-gaps.

The well known summer resorts of lake Mohonk and lake Minnewaska are on the summit of Shawangunk mountain, in Ulster county, so that the region has become familiar to a large number of visitors. Unfortunately, however, no description of its geology has ever been published and the meagre references in the report of Mather ‡ throw but little light on the subject.

During the autumns of the past two years I have had occasion to spend a few days on the mountain to determine the salient

* Published by permission of Professor James Hall, State Geologist, in advance of the Annual Report of the Geological Survey of New York.

† Pronounced "Shongum," according to the residents of the region.

‡ *Geology of New York, Report on the First Geological District*, 1842.

—*New Geogr. Mag.*, vol. VI, 1891.

features of its geology in Ulster county, and they were found to be of great interest. In this article there is presented a brief summary of the results of my observations, but in a report on the geology of Ulster county, now in preparation, there will be a somewhat more detailed description of the region.

The structure of Shawangunk mountain in Ulster county is a particularly interesting illustration of close relation of rock texture to topography, for the presence of the mountain and its form are directly dependent on the structure of a relatively thin sheet of hard rock. In the accompanying stereogram (plate I) an attempt has been made to represent its physiographic character, and the structure is shown in the cross-section at the ends of blocks into which the supposed model is divided. The mountain consists of a widely extended sheet of Shawangunk grit lying on soft Hudson shales. This sheet lies in a gently westward-dipping monocline which is corrugated by a series of gentle longitudinal flexures. To the westward it dips beneath shales and limestones of the succeeding formations in the Rosendale valley; to the eastward it terminates in long lines of high precipices which surmount steep slopes of Hudson shales. Its anticlinals give rise to high ridges and wide plateaus; its synclinals constitute in greater part the intervening depressions. In several portions of the mountain the grit has been eroded off the crests of the anticlinals and the underlying shales are bare. This is the case in a wide area southeast of Ellenville, in a long strip extending from near lake Mohawk nearly to Rosendale, in a small area east of Wawarsing, and in the top of the mountain north of lake Minerva. Mather has suggested that the great cliffs of the region are due to faults, but I find this is not the case. Only one fault was found, and this was a small overthrust in the Rosendale region. There are many slight faults of a few inches or feet, but they appear to be entirely in the grit.

The surface of Shawangunk mountain is nearly everywhere very rugged, and cliffs and rocky slopes abound. These consist of snow-white grits, more or less mantled with dark lichens, and are remarkably picturesque. There are many cataraets, several beautiful rock-behind lakes, and widely extended views of the Catskills to the westward and the Hudson valley to the eastward. The ruggedness is due to the exceptional hardness of the grits, the softness of the underlying shales, and a tendency to vertical jointing which gives rise to cliffs and cliffs.

There are low lines of cliffs all over the surface of the mountain, especially to the southward, but along the eastern face, where the grit is being continually undermined by erosion of the slate, they are of great prominence, in some cases having a nearly vertical height of two hundred feet and extending continuously for many miles. The "points" are projections or promontories of the eastern edge of the grit beyond the general crest line, due to a less degree of recession. Buntico point, Palts point, Gertrude nose and Sans point are the most prominent of these, but there are many others of minor importance. The cliffs on the surface of the ranges are of various heights and lengths, and rise along joint cracks. They face in various directions, but a north-and-south trend is predominant. They are usually in irregular, discontinuous steps on the slopes and face each other and enclose depressions of various sizes on the plateaus.

The lakes for which the mountain is famous lie in basins of moderate depth and are all near the top of the range. They are nearly surrounded by cliffs of Shawangunk grit of greater or less height, which add greatly to their beauty. The grit is mainly a massive white or gray quartzite or conglomerate, averaging 250 to 300 feet thick. The proportion of pebbles is large but variable, many beds being fine. The pebbles and grains are quartz, and the matrix is siliceous. The conglomerate is the famous Esopus millstone, and has been largely quarried for two centuries.

The relations of the Shawangunk grit to the Hudson shale on the Shawangunk mountain region is one of slight but persistent unconformity. The coarse grit lies directly on the eroded surface of the shales. This erosion has truncated low arches of the slate, but has channelled its surface only slightly. Exposures of the relations are everywhere abundant. One of the best instances is along the road from Minerva to New Palts, two miles south of lake Mohonk. Here along the mountain slope a very low arch of the grit is seen surmounting a truncated arch of shales of materially steeper dip. Diversity of dip is seen at every locality, varying from very slight to 10°, but several points were observed where it was hardly perceptible.

The corrugations in the general monocline of the mountain are a series of anticlinals and synclinals which traverse the range diagonally from north-northeast to south-southwest and begin in succession from northeast to southwest, their axes rising grad-

ally to the southward. Beginning at the northern end of the range the principal feature is the anticlinal which brings up the cement between Rosendale and Whiteport. South of Rondout creek, opposite Rosendale, the upward pitch of this flexure increases rapidly, and the Shawangunk grit soon rises into a ridge of considerable altitude. In a short distance from the creek the grit are eroded from the crown of the arch, and to the southward the underlying shales constitute a series of high but rounded hills extending along the center of the mountain. The occurrence of these high hills of soft rock is a striking feature, and they give a unique character to this portion of the mountain. Their presence is due to the former protection of the arch of Shawangunk grit by which they were originally covered. The grit in the flanks of this arch extends down the slopes of the mountain, where it dips beneath overlying formations in the valley on the western side and extends nearly or quite to the base on the eastern side. One mile and a half south of Rosendale the range has the structure shown in the first section on the stereogram. It will be seen that the sheet of grit lying along the eastern slope of the mountain is considerably corrugated. This corrugation correlates in the main of a western limb dipping more or less steeply eastward, and a shallow synclinal. In one portion of the ridge, there is a very abrupt anticlinal crumple in this synclinal which extends but a short distance in either direction and then flattens out into the general flexure. There is also a fault which extends from the Rosendale cement region. It gives rise to a sharp ridge which continues to the first road across the mountain, beyond which it dies out. Along the eastern face of the northeastern range of the mountain the dips are in greater part gently to the westward. Along the railroad they are 20° , and this is the average for some distance. On the first road across the mountain the dips are 40° , but this steep dip soon gives place to inclinations of not over 10° , and toward the southern end of the ridge the synclinal dies out, leaving a gentle dip eastward. This grit area lying along the eastern slope of the mountain terminates abruptly southward in a fine line of cliffs which, owing to the upward pitch of the bed in this direction, are of great elevation. This is Bantico point, one of the most prominent topographic features in the region. Its character is shown in the stereogram.

South of Bantico point the eastern crest and summit of Shawan-



EAST MOUNTAIN LOOKING SOUTHWEST

[illegible][illegible]

South of the gentle rise is a low ridge by the river
about a mile long, the drainage kept from the rock west
ward. The western ridge rises gradually on the upward slope of
the river at the the river. Finally becoming the last rise just as
the river turns east of the city. South west of Lake Mendocino
the river is one of the best to run, it is not so good as the others, but it
is a good one, with a creek in the back of it. The river is a good one
but it is not so good as the others, it is not so good as the others, and it is
not so good as the others, it is not so good as the others, and it is

They are not as colorful as the other species of the genus and are not as large. They are smaller and have a more slender body. They are also more common in the mountains of the Andes.

There is a brown, low, covered bridge over the river, which is the only bridge in the district. It is a very old one, and is in a very poor state of repair. The bridge is made of logs, and is very narrow. The only way to get to the bridge is to go down the trail on the west side of the river. The bridge is very old, and is in a very poor state of repair. The bridge is made of logs, and is very narrow. The only way to get to the bridge is to go down the trail on the west side of the river. The bridge is very old, and is in a very poor state of repair. The bridge is made of logs, and is very narrow. The only way to get to the bridge is to go down the trail on the west side of the river.

[illegible]

It is of a *Staphylococcus* type, but the form is not typical of the *Staphylococcus*

[illegible]

The last of the unknowns that a parent has to face is the school. Although parents have to choose a school for their child, they have no say in the school's curriculum or its teaching methods. The only way to influence the school is by choosing a school that is known for its good reputation.



Between which flows along the western edge of the hill a mile, and then a high ridge over the gap into the hill. East of this ridge there is a narrow depression known as Darkling, which extends south-eastward up the slope of the mountain. It is bounded by gently sloping hills of water-rough ground, and is a grassy stream-bed, except on a few patches. On the northern side of Darkling is a high place, and when it is reached from the south the cliffs of the mountain are of dark limestone.

20. Let us follow the highway for a long way or even extend along the western flank of the great and not much lake. At the same time, as I have a cliff of wood-shed, the great on his western side and a part of great on the eastern side. For on his last day lake. We set on the hill passes over a washing for a time then over a series of small hills, increasing in height to a height of over 2400 ft. approximately. In the setting of the there is a great fall of a river and some. They are a mile north of lake Samnawake. In the gorge below the several falls there are high cliffs of great for some distance, but owing to some being too high to ascend and some of them are not a good road of great or upward of 2000 ft. the hill is not a good road for the horse. It is a steep slope.

So, at the lake Anestog is the northernmost of those ponds on the summit of the mountain. Half past 7 at the top of the mountain, the edge of the fork of the forked hill is seen as Lake Marmah is just over. Lake Marmah is except as a small lake. The fork of the forked hill pitches over the edge of the mountain. The crest of the mountain is a great all over a high ridge of the forked hill. The locality is known as Verke or a falls.

[illegible]

In this region the forest is more continuous, more difficult to pass and the vegetation varied. The narrowing is due to the presence of the edge of the sheet of the snow-capped part, which is covered by the narrow part of the tundra. The patch increases the height of the mountain and the width of the forest height.

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there is a corresponding increase of erosion in the soft underlying shale, which beyond certain limits causes topographic inversion. This is illustrated by Sams point, where the maximum altitude of 2,960 feet is attained. The "point" is a narrowing extension of the grit along the axis of a very deep canyon, which only temporarily may have a narrower cliff presented to the river. It is a narrow arched area to the west the grit has been eroded and the Hallowell shales occupy the surface in a group of very high ridges. These ridges are separated by crevices of the grit which on the eastern side rise somewhat above the surrounding level. The granite also rises with the higher summits, and on the western horizon the granite flanks. Originally the grit area in this region and southward was as wide as it is now at Lake Umbagog, but owing to the greater height to which the postglacial pitch of the flexure carried the grit, it was soon more rapidly and widely obliterated and removed. It is the grit on the western side of the point that has on the western flank of the shale by its resistance and nature, and a zone of coarse boulders pebbles, which extends from 12 miles or far southward into Putney valley. This formation on Putney consists of a single crested ridge of the Shawangunk grit with a long slope up the crest from the valley westward, which becomes in an eastward dip of grit with an increasing slope of shale on the eastern side of the mountain. The structure near the mountain edge of a later erosion is seen in the bottom area at Putney a deep cut, and this is typical for the greater part of the course of the valley westward. There is a depression of land, as well as the grit, as shown on the left of the section, also. There are the Clinton red shales which water has eroded, leaving an exposed, crinkly surface below, but as a whole the rugged limestone and a great mass of Devonian shales and sandstones which extend into the Father He. The dips along the western margin of the grit are toward west of Wyanet 2, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 260, 270, 280, 290, 300, 310, 320, 330, 340, 350, 360, 370, 380, 390, 400, 410, 420, 430, 440, 450, 460, 470, 480, 490, 500, 510, 520, 530, 540, 550, 560, 570, 580, 590, 600, 610, 620, 630, 640, 650, 660, 670, 680, 690, 700, 710, 720, 730, 740, 750, 760, 770, 780, 790, 800, 810, 820, 830, 840, 850, 860, 870, 880, 890, 900, 910, 920, 930, 940, 950, 960, 970, 980, 990, 1000, 1010, 1020, 1030, 1040, 1050, 1060, 1070, 1080, 1090, 1100, 1110, 1120, 1130, 1140, 1150, 1160, 1170, 1180, 1190, 1200, 1210, 1220, 1230, 1240, 1250, 1260, 1270, 1280, 1290, 1300, 1310, 1320, 1330, 1340, 1350, 1360, 1370, 1380, 1390, 1400, 1410, 1420, 1430, 1440, 1450, 1460, 1470, 1480, 1490, 1500, 1510, 1520, 1530, 1540, 1550, 1560, 1570, 1580, 1590, 1600, 1610, 1620, 1630, 1640, 1650, 1660, 1670, 1680, 1690, 1700, 1710, 1720, 1730, 1740, 1750, 1760, 1770, 1780, 1790, 1800, 1810, 1820, 1830, 1840, 1850, 1860, 1870, 1880, 1890, 1900, 1910, 1920, 1930, 1940, 1950, 1960, 1970, 1980, 1990, 2000, 2010, 2020, 2030, 2040, 2050, 2060, 2070, 2080, 2090, 2100, 2110, 2120, 2130, 2140, 2150, 2160, 2170, 2180, 2190, 2200, 2210, 2220, 2230, 2240, 2250, 2260, 2270, 2280, 2290, 2300, 2310, 2320, 2330, 2340, 2350, 2360, 2370, 2380, 2390, 2400, 2410, 2420, 2430, 2440, 2450, 2460, 2470, 2480, 2490, 2500, 2510, 2520, 2530, 2540, 2550, 2560, 2570, 2580, 2590, 2600, 2610, 2620, 2630, 2640, 2650, 2660, 2670, 2680, 2690, 2700, 2710, 2720, 2730, 2740, 2750, 2760, 2770, 2780, 2790, 2800, 2810, 2820, 2830, 2840, 2850, 2860, 2870, 2880, 2890, 2900, 2910, 2920, 2930, 2940, 2950, 2960, 2970, 2980, 2990, 3000, 3010, 3020, 3030, 3040, 3050, 3060, 3070, 3080, 3090, 3100, 3110, 3120, 3130, 3140, 3150, 3160, 3170, 3180, 3190, 3200, 3210, 3220, 3230, 3240, 3250, 3260, 3270, 3280, 3290, 3300, 3310, 3320, 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9970, 9980, 9990, 10000.

small and have only formed narrow gorges. Opposite Napanoch is a small creek which has cut a deep gorge into the shales, and in the higher part of the slope has bared the grit from an area of considerable size, which is surrounded by high cliffs. The stream opposite Wawarsing has cut a gorge and removed an area of the grit on the upper slopes of the mountain, but does not cut through to the shale. The head of this depression extends into the head of the depression opposite Napanoch, and both are surmounted on the east by a continuous line of high cliffs. The stream which flows out of the mountain at Port Jervis is larger than the others and has cut a deep, wide gorge; but owing to the lower dip of the grit it does not appear to have cut through to the shales to any great extent. No shales were observed in place in the depression, but a small amount of shale debris was noticed at one point. Everywhere along the steep slopes there are clefts in the grit, some of which appear to extend down to the shales. One of these is the "Ice cave," a locality which is widely famous in the region. It is high in the slope, about two miles east-northeast of Ellenville. Ice and snow remain in it in greater or less amount, and in some seasons they are preserved entirely through the summer and autumn. In the vicinity there is also an old copper mine from which large supplies of fine quartz crystals were obtained some years ago. The top of the mountain southwest of Wawarsing is a wide plateau which is traversed by the valley of Stony creek. Its surface is very irregular and low cliffs of the bare grit abound.

The grit in the higher portion of Shawagunk mountain nearly everywhere presents a basined surface. These basins are depressed an inch or two below the general level and are of various sizes and shapes. They usually contain pools of water and some sand and pebble detritus. They are mostly smooth and even polished and are distributed all over the mountain, but particularly on the western slope. With the polishing are associated lines of glacial scorings and striation which are conspicuous at nearly every locality. Jullien* has recorded the direction of some of these striae and scorings. The general direction is southwestward and the average depth is between one sixteenth and one-eighth of an inch. In the vicinity of Sams point the most abundant scratches trend south 45° west and south 22° west.

* New York Academy of Sciences, Trans., vol. III, pp. 72-20.

A few were observed somewhat more to the westward in direction, one-fourth inch in depth.

In the vicinity of lake Mohonk, about the hotel and on the northwestern slope, south 10° west is the general direction; on the southeastern side of the mountain and on the road to Allgertville, it is south 40° east; and at Sky Top, south 18° east. At lake Minnewaska the trend is south 10° west. There is but little foreign glacial drift on the summit of the range, so far as observed, but there is considerable in the adjoining valleys.

The origin and history of the lakes are not entirely clear, but they appear to be due to glacial agencies. The principal feature has been a local deepening and widening of a pre-existent valley, aided, at least in the case of lake Mohonk, by the presence of shales at the point now occupied by the lake. They do not appear to be due in great measure to damming by glacial or other debris or to dislocation.

Owing to its prominence the mountain has been long exposed to erosion. Originally the grit was overlain by a great mass of limestones and shales and the rocks of the Catskills, but these were removed far down into the Rondout valley at an early period. During the glacial epoch there was great erosion and the removal of great masses of the grit, which is now found in drift far to the southward. To the glaciation, too, probably is due the abruptness of Paltz point and other features of that sort. The grit also originally extended far to the eastward, but, owing to long-continued undermining by the removal of the soft, underlying shales, its front has receded to its present position. This recession is still actively in progress, and every year there fall great masses from the front of the mountain. One of the regions of weakness is Paltz point, for its base is exposed to erosion on several sides, and it will eventually disappear. Probably before it is gone the streams heading near its southern end will cut back through the shales at the head of lake Mohonk, and this beautiful body of water will be tapped. Of course this is all very remote, so far as human history goes, and artificial means will delay its progress in some measure, but it will all be accomplished in the near future, geologically speaking. Lakes Minnewaska and Awosting lie so far back from the front of the mountain that they will survive lake Mohonk by a very long time.

